

Two New Species of *Clinopsalta* Moulds (Hemiptera: Cicadidae) and Additional Distribution Records for *Clinopsalta adelaida* (Ashton), with Notes on their Distinctive Calling Songs

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ABSTRACT. Two new species are described in the genus *Clinopsalta* Moulds. *Clinopsalta autumnna* sp. nov. exhibits a warm temperate distribution from south-east Queensland south to Goulburn and Nerriga in eastern New South Wales. *Clinopsalta semilunata* sp. nov. has a patchy distribution in southern Queensland from Binjour Plateau west to near Miles, south to Yelarbon State Forest and Durikai State Forest, both near Inglewood. In addition to the descriptions of these new species, further distribution records are provided for *C. adelaida* (Ashton), which extend its distribution from south-eastern South Australia and northern Victoria to inland central and northern New South Wales. The species of *Clinopsalta* are small–medium sized cicadas (< 20 mm body length) with distinctive calling songs of an intermediate frequency (c. 6 to 18 kHz). The temporal structures of the calling songs follow a similar pattern in each species, comprising an introductory rattle followed by a series of clicking phrases. The call is characteristically accompanied with bouts of prominent wing-snapping, except in one species (*C. semilunata* sp. nov.).

KEYWORDS. Cicadettini; bioacoustics; taxonomy

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This stand-alone study forms part of the ongoing taxonomic treatment of Australian cicadas. Many of the smaller cicada species across the world (tribe Cicadettini) exhibit brief seasonal appearances, which can only be intersected by regular and opportunistic fieldwork. The success of such fieldwork has relied heavily upon the readily detectible calling songs produced by these insects (e.g., Ewart, 1988,

1989, 1998, 2005; Simões *et al.*, 2000; Ewart & Popple, 2001; Popple & Strange, 2002; Sueur, 2002; Sueur & Aubin, 2004; Pinto-Juma *et al.*, 2005; Quartau & Simões, 2006; Seabra *et al.*, 2006; Popple *et al.*, 2008; Ewart & Popple, 2013a,b). The male calling songs provide an effective and often instantaneous method for identifying known species and a definitive method for revealing new species.

The genus *Clinopsalta* was introduced by Moulds (2012) as part of a substantial taxonomic revision of Australian cicadas. Two species, previously located in *Cicadetta* Kolenati, were transferred to this genus: *Clinopsalta adelaida* (Ashton, 1914) and *C. tigris* (Ashton, 1914).

In this paper, we describe two new species of *Clinopsalta* and provide new distribution records for *C. adelaida*. A detailed description and comparison of the calling songs of these three species is also presented.

Methods and terminology

Anatomical terminology follows Moulds (2005, 2012) for body structures and wing characters, Moulds (2005) for genitalia, and Dugdale (1972) and Bennet-Clark (1997) for timbals. The long timbal ribs are referred to as long ribs 1 to 5, with long rib 1 being the most posterior (adjacent to timbal plate). The higher classification adopted in this paper follows Moulds (2012). Measurements (in mm) are given as Means and ranges (in parentheses) and include the largest and smallest specimens. Head width spans across the eyes; pronotum width across the extremities of the lateral margins; abdomen width is measured across the outer edges of the auditory capsules.

Material sourced for this taxonomic work is located in collection abbreviated as follows: *AE*, private collection of A. Ewart, Caloundra; *AM*, Australian Museum, Sydney; *DE*, private collection of D. L. Emery, Sydney; *MC*, private collection of M. Coombs, Brisbane; *QM*, Queensland Museum, Brisbane; *MSM*, private collection of M. S. Moulds, Kuranda; *LWP*, private collection of L.W. Popple, Brisbane.

Genitalia preparation. Male genitalia were removed using a pair of surgical scissors and placed in a solution of 10% potassium hydroxide. The solution was either boiled for one hour or left overnight at room temperature to clear the soft tissues and provide a clean dissection. Following clearing, the specimens were washed with ethanol and placed into a solution of either 70% ethanol or glycerol. To facilitate close examination of internal structures, the aedeagus was dissected for each genitalia preparation under 10× magnification. Measurements were taken using a pair of Toledo vernier calipers (accurate to 0.1 mm).

Calling song analysis. The calling song terminology used in this study has been modified from Ewart and Marques (2008). A “pulse” was defined as a single complete movement of the timbals. The term “syllable” was used for the smallest grouping of pulses (typically 5–10 ms duration). Where 2–9 syllables coalesce, this was referred to as a “macrosyllable”. Longer durations of continuous sound (≥ 10 syllables) were referred to as an “echeme”. A period of silence following a syllable, macrosyllable or echeme is treated as a “gap”. Where a series of syllables is produced without coalescence (i.e. with each syllable separated by a gap), this is referred to as a “syllable sequence”.

Field recordings have been used throughout. All recordings were made at a distance > 20cm from the calling insect to reduce the chances of near-field effects. None of the recordings showed signs of amplitude clipping due to microphone overload.

The recording systems (RS) used can be detailed as follows: *RS1*, Sony MZR700 minidisc recorder with Sony ECM-MS957 Electret Condenser microphone; *RS2*, Tascam DR-40 digital recorder with a Sennheiser K6/ME66 or ME67

microphone; *RS3*, Marantz PMD670 digital recorder with a Telinga Pro 6 parabolic microphone; *RS4*, Tascam DR-07 digital recorder with an Audio Technica ATR-55 microphone; and *RS5*, Sony WM-D6C Walkman with Sennheiser K6/ME66 microphone.

All recording equipment exhibits a reliable frequency response up to 18 kHz. Processing and analysis of recordings was undertaken with Cool Edit Pro (version 2.1) and Audacity (version 2.1.2) software. Amplitude spectra were generated using a linear frequency axis on a 1024-point Fast Fourier Transform with a Hamming window function.

Systematics

Family Cicadidae Latrielle, 1802

Subfamily Cicadettinae Buckton, 1889

Tribe Cicadettini Buckton, 1889

Genus *Clinopsalta* Moulds, 2012

Diagnosis follows Moulds (2012).

Clinopsalta autumn sp. nov.

Figs 1–4

Cicadetta sp. nr *adelaida* 214: Emery et al. (2005).

Holotype: 1♂, Mt Annan Gardens, Narellan, NSW, 31°18.14'S 149°02.05'E, 29.ix.2009, N. Emery (AM, K.504498). **Paratypes:** 1♂, southeast Queensland, 28°03'S 152°22'E, Cunninghams Gap, via Aratula, 26.xii.1997, C. J. Burwell, QM reg. no. T237102 (QM); 1♂, 3 km E Wedderburn, NSW, 15.xi.2003, D. Britton; 2♂♂1♀, Beach Road, Harley Hill nr Berry, NSW, 34°46.40'S 150°44.01'E, 24.xii.1994, D. Emery (AM, K.504499–501); 1♂, same location, 27.xii.2002, S. and D. Emery; 2♀♀, same location, 2.xi.1997, S. and D. Emery; 1♀, same location, 30.xii.2002, S. and D. Emery; 1♂, Burragorang Rd, The Oaks, NSW, 34°04.10'S 150°28.28'E, 400 m, 14.xi.2003, S. and D. Emery; 3♂♂1♀, Prospect Reservoir, NSW, 33°48.48'S 150°54.48'E, 14.xi.1997, D. Emery; 2♂♂, same location, 5–11.xi.1998, D. Emery; 1♀, same location, 2.xi.1997; 1♀, same location, 17–21.xi.1997; 2♂♂1♀, same location, 5.i.1998, D. Emery; 4♂♂, same location, 11–26.xi.1998, D. Emery; 2♂♂2♀♀, Hume Highway, Pheasants Nest nr Bargo, NSW, 34°16.58'S 150°38.20'E, 1.xii.2003, D. Emery and L. Popple; 2♂♂, Littlefields Rd, Mulgoa, NSW, 33°50.32'S 150°40.35'E, 4.xii.2000, N. Emery; 1♀, Littlefields Rd, Mulgoa, NSW, 33°50.32'S 150°40.35'E, 5.xi.2000, N. Emery (all DE); 1♂, Prospect Res, 11.xi.1998, D. Emery, 214-0001; 1♀, Prospect Res, 26.x.1998, D. Emery, 214-0002; 1♂, Cunningham's Gap, southeast Queensland, 6.Jan.2001, L. Popple, J. Moss, 214-0003; 1♂1♀, same data as previous, 12.xi.2001, 214-0004, 214-0006; 1♂, same data as previous, 31.i.1999, 214-0005; 3♂♂1♀, Australia NSW, Bargo, *Ac[acia] parramattensis*, 1.Dec.2003, L. Popple, D. Emery, 214-0008–214-0011 (all LWP); 1♂, Milperra, NSW, 7.xii.1976, G. R. Brown; 1♂1♀, Harley Hill, 18.xii.1995, D. Emery; 2♂♂2♀♀, Menai, W. of Sutherland, Sydney, NSW, 14.xi.1983, R. Eastwood (all MSM).

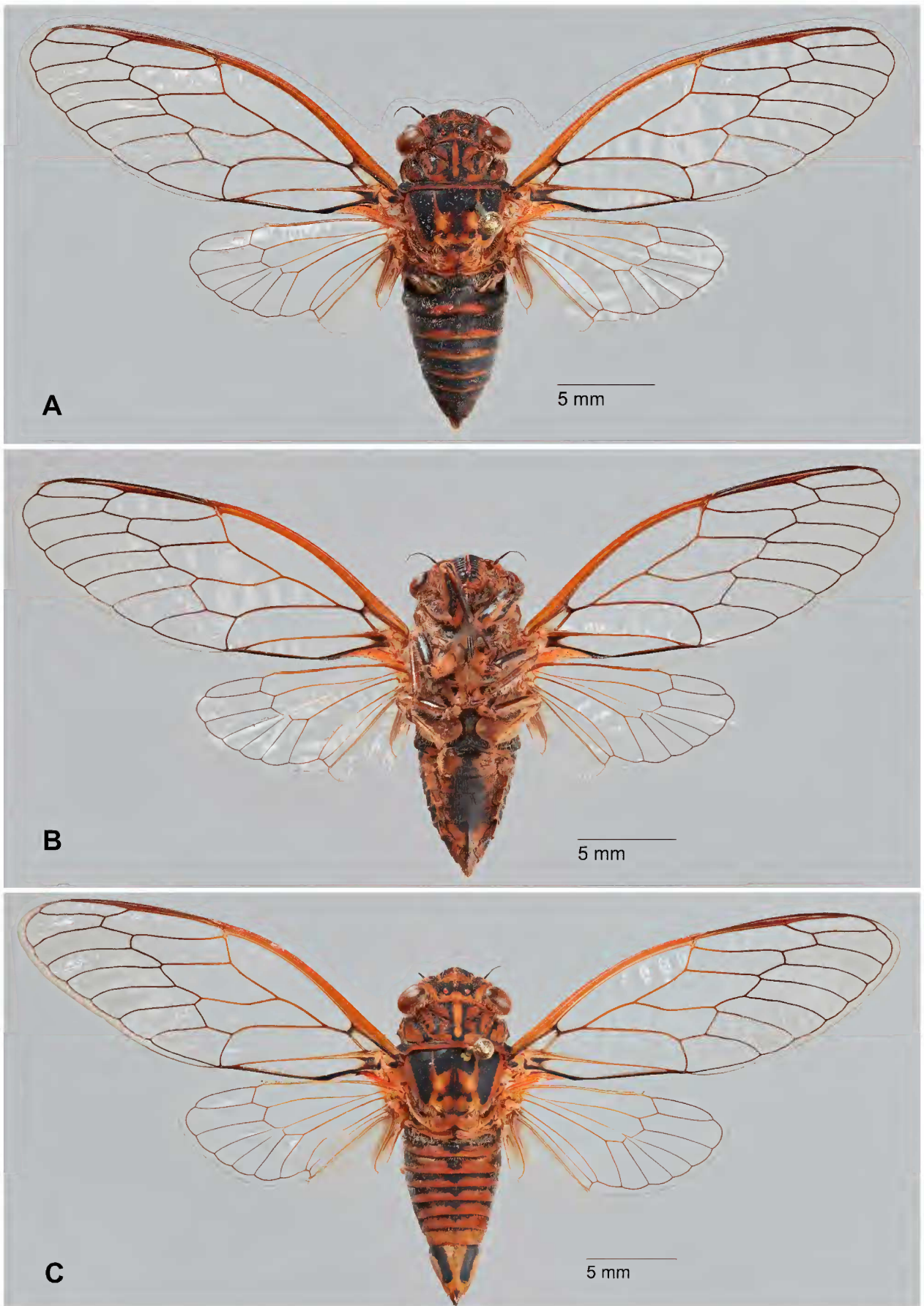


Figure 1. *Clinopsalta autumnna* sp. nov. (A) male, Narellan (31°18.14'S 149°02.05'E) dorsal habitus; (B) male, ventral habitus; (C) female, Narellan (31°18.14'S 149°02.05'E), dorsal habitus.

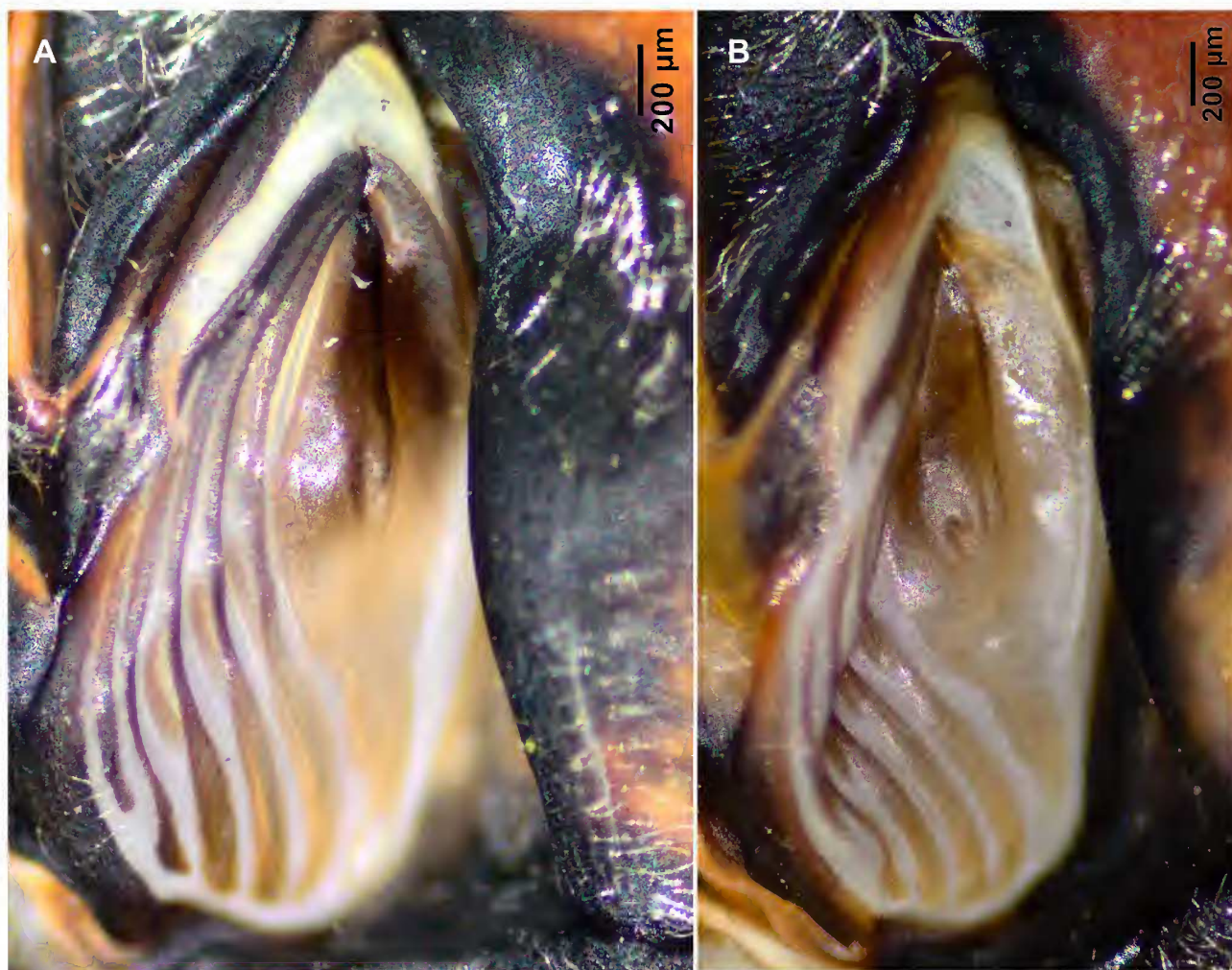


Figure 2. Photos of male left timbals, with dorsal edge at top and posterior margin at right: (A) *Clinopsalta autumnata* sp. nov., Narellan (31°18.14'S 149°02.05'E); (B) *Clinopsalta semilunata* sp. nov., Roma (26°33'S 148°47'E).

Other material examined. 1♂, Beach Road, Harley Hill nr Berry, NSW, 34°46.40'S 150°44.01'E, 15.i.1993, T. Emery; 2♂♂, same location, 18–22.xii.1995, D. Emery; 1♂, same location, 1.i.2001, D. Emery; 2♂♂, Prospect Reservoir, NSW, 33°48.48'S 150°54.48'E, 11.x.1998, D. Emery; 3♂♂, Burratorang Rd, The Oaks, NSW, 34°04.10'S 150°28.28'E, 400 m, 18.xi.2003, D. Emery; 3♂♂, Littlefields Rd, Mulgoa, NSW, 33°50.32'S 150°40.35'E, 14.xi.2007, D. Emery; 3♂♂1♀, Mt. Hunter, NSW, 15.xii.2005, D. Emery; 1♂, Mt. Annan Gardens, Narellan, NSW, 31°18.14'S 149°02.05'E, 24.ix.2011, N. Emery; 1♀, same location, 29.x.2009, N. Emery; 1♂, Kentlyn, NSW, 34°02.52'S 150°53.09'E, 1.xi.2009, N. Emery; 1♂, Endrick River nr Nerriga, 35°05.17'S 150°06.59'E, 1.i.2015, S., N., C., and D. Emery (all DE).

Additional locations with audio recordings. Mountain Rd, Bauple, Qld, 25°48'29"S 152°35'15"E; Razorback Road, West Haldon, Qld, 27°43'44"S 152°06'53"E; Stirling Road Reserve, Rosewood, 27°36'33"S 152°36'36"E; Governor's Chair, Spicers Gap, Qld, 28°05'08"S 152°25'04"E; Redwood Park, Withcott, Qld, 27°33'53"S 151°59'56"E; Carysfield Park, Bass Hill, NSW, 33°54'10"S 150°59'54"E (all LWP).

Description. Male (Figs 1A,B; 2A; 3). *Head.* Supra-antennal plate and vertex black, with areas of orange-brown colouration extending laterally from dorsal anteriormost

edges of postclypeus; frons black with a contrasting area of brown colouration extending anteriorly from median ocellus; mandibular plates and genae black, each with a narrow orange-brown margin and covered by silver–yellow pubescence; small median orange-brown triangular fascia, extending and widening posteriorly from near median ocellus to pronotal margin along the epicranial suture; ocelli pink to red; compound eyes red when alive, brown to dark brown in stored specimens. Postclypeus predominantly black, orange-brown along margins and between the transverse ridges; anterior median area coloured pale orange-brown or reddish-brown; anteclypeus mainly black; rostrum dark brown; antennae dark brown.

Thorax. Pronotum mainly medium brown, with an orange-brown medial fascia, bordered with black colouration that widens anteriorly of pronotal collar and also towards proximal margin; dorsal and lateral fissures black; pronotal collar reddish-brown to brown, with lateral margins amplate and often black. Mesonotum with submedian sigilla black, fused anteriorly, with rounded posterior terminations; lateral sigilla black, sharply defined, elongated and narrowing posteriorly; area posterior of submedian sigilla with yellow highlights, often dark brown to black medially; remainder of mesonotum, including lateral edges adjacent to lateral sigilla, area surrounding scutal depressions and length of

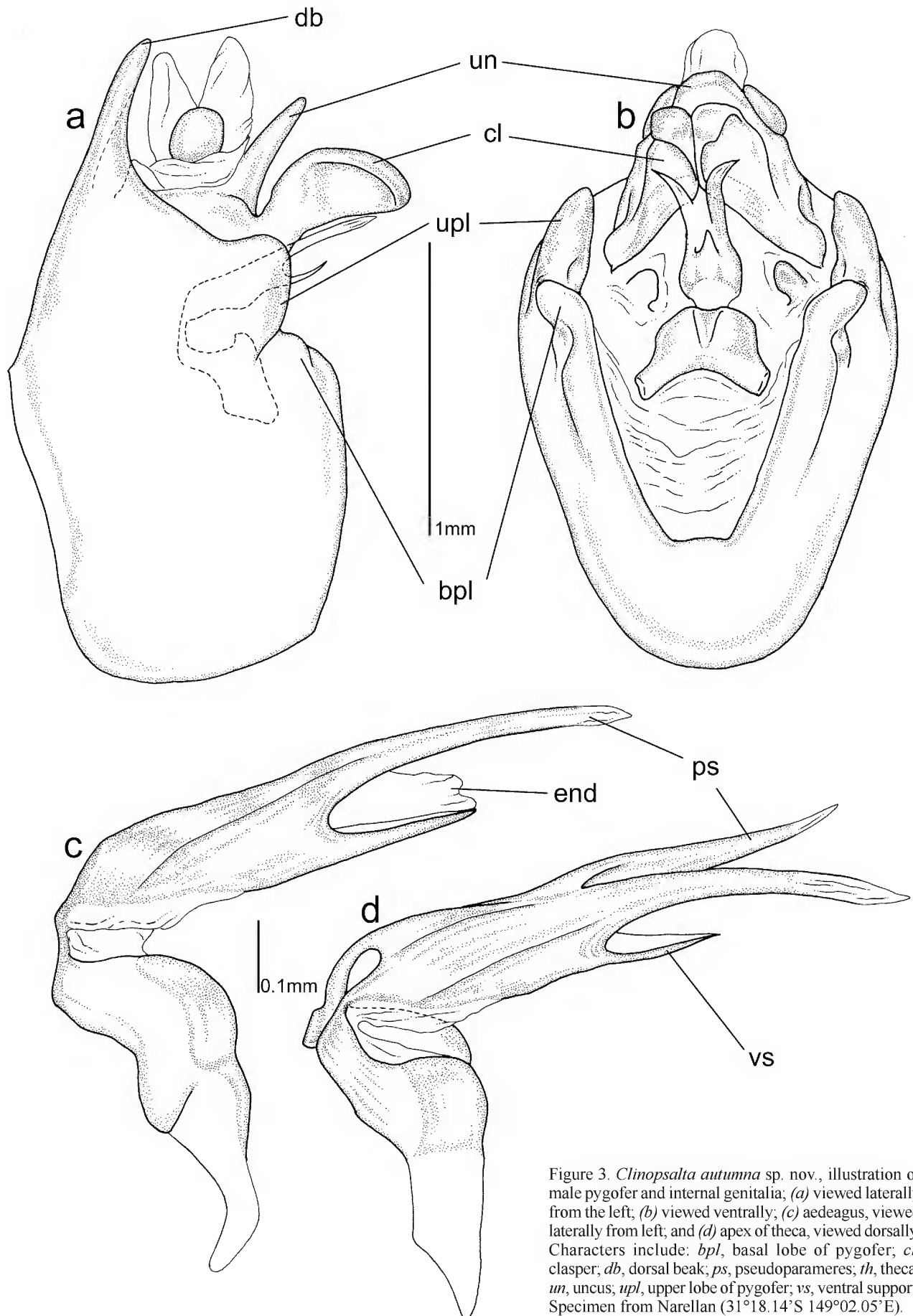


Figure 3. *Clinopsalta autumnna* sp. nov., illustration of male pygofer and internal genitalia; (a) viewed laterally from the left; (b) viewed ventrally; (c) aedeagus, viewed laterally from left; and (d) apex of theca, viewed dorsally. Characters include: *bpl*, basal lobe of pygofer; *cl*, clasper; *db*, dorsal beak; *ps*, pseudoparameres; *th*, theca; *un*, uncus; *upl*, upper lobe of pygofer; *vs*, ventral support. Specimen from Narellan (31°18.14'S 149°02.05'E).

parapsidal suture between submedian and lateral sigilla, brown; scutal depressions black; cruciform elevation brown to dark brown; mesonotum with inconspicuous and sparse silvery-yellow pubescence, more apparent adjacent to wing grooves. Metanotum brown; black medially.

Wings. Fore wing costal vein translucent, orange-brown from base to node, dark brown along remainder; other venation brown, darker proximally; basal membrane orange. Hind wing venation brown, with light brown opaque plaga around margins of anal cell 3, adjacent to vein 3A and vein 2A; six apical cells.

Legs. Coxae and trochanters predominantly pale to medium brown with irregular black fasciae on anterior, lateral and posterior faces; meracantha spikes dark brown with paler lateral margins, slightly overlapping opercula; fore, mid and hind femora medium (or sometimes pale) brown with dark brown longitudinal fascia developed on posterior, dorsal and anterior faces; fore and mid tibiae mainly dark brown; hind tibiae pale brown; tarsi a mixture of pale, medium and dark brown; claws brown, darker apically; spines of fore femora black.

Opercula (Fig. 1B). Broadly rounded; predominantly brown; plates undulating with medial areas slightly depressed.

Timbals (Fig 2A). Five long ribs; ribs 4–5 both unattached to adjacent ribs and shorter than ribs 1–3; ribs 1–3 fused dorsally, but not ventrally.

Abdomen. Tergite 1 dark brown to black; tergite 2 brown on dorsal surface, black laterally; remaining tergites mainly reddish-brown, becoming paler posteriorly, with areas of black colouration anteriorly, extending posteriorly along dorsal midline and along lateral edges, especially on tergite 3; silvery pubescence most prominent along lateral edges of anterior tergites; tergite 8 dark brown to black. Sternite II brown to orange-brown, with median area of black colouration broadening posteriorly; sternites III to VII brown to orange-brown, with broad and prominent black medial triangular areas, pointed anteriorly, weaker, smaller and sometimes restricted to anterior edge of sternite VII; sternite VIII brown; intersegmental membranes brown.

Genitalia (Fig. 3). Pygofer with black colouration dorsally, extending to beak and along anterior lateral edges; medium brown over the remainder; claspers conspicuously elongated, extending posteriorly beyond termination of pygofer, bluntly rounded apically; uncus vertically narrow, relatively short, with rounded termination; pseudoparameres clearly longer than endotheca; endotheca soft and fleshy.

Female. (Fig. 1C). Similar to male in general colouring and patterning, with more extensive areas of paler colouration.

Head. Supra-antennal plate and vertex brown anteriorly, black posteriorly; frons black with brown anterior margins and a contrasting area of brown colouration extending anteriorly from median ocellus; mandibular plates and genae brown; small median orange-brown triangular fascia, extending and widening posteriorly from near median ocellus to pronotal margin along the epicranial suture; ocelli pink to red; compound eyes brown to dark brown. Postclypeus black with median area coloured pale orange-brown or reddish-brown; orange-brown along margins and between the transverse ridges; anteclypeus mainly black, reddish-brown medially; rostrum brown, darker posteriorly; antennae dark brown.

Thorax. Pronotum as in male. Mesonotum with submedial sigilla black, fused anteriorly, with rounded posterior terminations, often shorter than in male; lateral sigilla black, sharply defined, elongated and narrowing posteriorly, as in male; cruciform elevation brown to dark brown; remainder of mesonotum mainly brown, as in male; mesonotum with inconspicuous and sparse silvery-yellow pubescence, more apparent adjacent to wing grooves. Metanotum brown; black medially.

Legs. Coxae and trochanters predominantly pale to medium brown with irregular black fasciae on anterior, lateral and posterior faces; fore, mid and hind femora medium (or sometimes pale) brown with dark brown longitudinal fascia developed on posterior, dorsal and anterior faces; fore tibiae mainly dark brown; mid and hind tibiae pale brown; tarsi a mixture of pale, medium and dark brown; claws brown, darker apically; spines of fore femora black.

Abdomen. Tergites 1–8 brown to reddish brown, sometimes dark brown to black anteriorly, with lines of black colouration extending along anterior dorsal and lateral margins; abdominal segment 9 brown to reddish-brown, with a pair of black dorsolateral fasciae, extending from the anterior margin and not reaching the posterior margin and with a localized black spot on posterior lateral surface. Sternite II brown to orange-brown, with median area of black colouration broadening posteriorly; sternites III–VII brown to orange-brown, with broad and prominent black medial, broadly triangular, areas, pointed anteriorly; sternite VIII brown; intersegmental membranes brown. Ovipositor sheath not extending noticeably beyond the posterior termination abdominal segment 9.

Measurements (in mm; range with mean in parentheses: 12 males, 9 females). Body length: male 16.2–17.9 (17.1); female (incl. ovipositor) 15.0–18.8 (18.0). Fore wing length: male 20.3–22.2 (21.4); female 19.1–24.5 (23.0). Forewing length/width ratio: male 2.53–2.79 (2.62); female 2.63–2.81 (2.75). Head width: male 5.9–6.8 (6.3); female 5.9–6.8 (6.3). Pronotum width: male 5.3–6.0 (5.6); female 5.3–6.3 (6.0). Abdomen width: male 5.5–6.3 (5.9); female 5.6–6.6 (6.1).

Distinguishing features. *Clinopsalta autumnna* sp. nov. can usually be distinguished from the *C. tigris* species complex by the complete lack of fore wing infuscations. However, on rare occasions, specimens in the *C. tigris* species complex also lack wing infuscations. In this case, *C. autumnna* sp. nov. can still be distinguished by having a predominantly dark brown rostrum (cf. mainly brown or olive in paler specimens of *C. tigris*). In addition, *C. autumnna* sp. nov. can be distinguished from *C. semihunata* by the broad, black markings on the centre of the sternites. It can be distinguished from the superficially similar *C. adelaida* by the presentation of forewing vein M3+4, which is distinctly kinked at the intersection with the nodal line. By contrast, in *C. adelaida*, forewing vein M3+4 is straight proximal to the nodal line intersection and only subtly curved over the remainder.

Distribution, habitat and behaviour. This species occupies a warm temperate distribution in eastern Australia from Mt Bauple, near Maryborough and the Bunya Mountains in south-east Queensland south along the Great Diving Range and subcoastally to near Goulburn, Nerriga and near Berry in southern New South Wales (Fig. 4). The paucity of records between the Border Ranges and the Greater Sydney regions

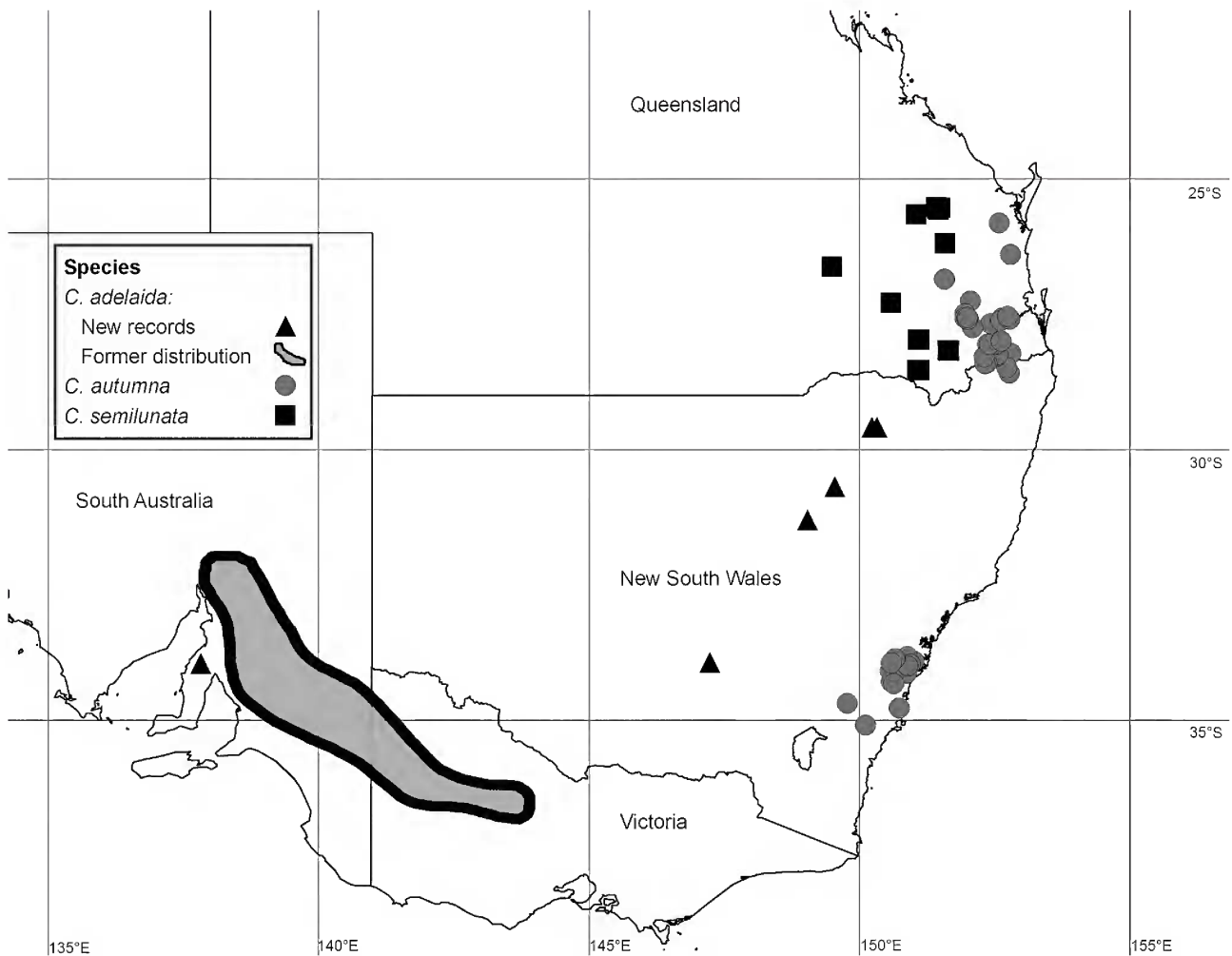


Figure 4. Map of central and eastern mainland Australia showing the geographical distribution of *Clinopsalta adelaida* (black triangles), *C. autumnna* sp. nov. (grey circles), *C. semilunata* sp. nov. (black squares). The former distribution of *C. adelaida* is sourced from Moulds (1990).

in New South Wales likely reflect lack of observation or specimen collecting rather than a distribution disjunction, although populations may be patchily distributed. Adults occur in association with wattles, particularly those that retain juvenile foliage (fern-like leaves) as adults, such as *Acacia irrorata* and *A. parramattensis*. Hickory wattles, including *A. falcata* and *A. falsiformis*, are also inhabited in some areas (Emery *et al.*, 2005). Males call from main branches typically in the upper foliage of wattles. Observations suggest that they tend to remain fairly static, but will relocate quickly at the first sign of disturbance. Adults have been observed between early September and early February.

Etymology. From the Latin word *autumnus*, meaning “autumn”. The name is a reference to the various colours of this cicada matching those of autumn leaves in a deciduous forest.

Clinopsalta semilunata sp. nov.

Figs 2B; 4–6

Notopsalta sp. F: Ewart (1998).

Holotype: ♂, AUSTRALIA QLD, Old Thanes Creek Road, Pratten, 1.xi.2015, Recorded, L. W. Popple, 28.0912°S 151.7360°E, 211-0008, QM reg. no. T237103 (QM). **Paratypes:** 1♀ AUSTRALIA Queensland, 6 km west of Thane, 11.xii.2001, hand-collected, L. W. Popple 28°09'41"S 151°57'59"E, 211-0006, QM reg. no. T237104 (QM); 1♂, Jct. Engineer-Auburn Rds., Chinchilla, S. Qld., 10 Oct 1997. Recorded; 1♂, Wongongera Ck., Miles, S. Qld. 26°30.68'S 150°29.30'E, 3 Oct 1997; 1♂, “Red Ridge”, Miles, S. Qld. 26°47.34'S 150°23.85'E, 2 Oct. 1997 (all AE); 2♂♂, 70 km E. Roma, Qld, 26°37.1'S 149°29.40'E, 19.x.2011, N. C. and D. Emery (both DE); 4♂♂ 1♀, AUSTRALIA Queensland, 6 km west of Thane, 11.xii.2001, hand-collected, L. W. Popple 28°09'41"S 151°57'59"E, 211-0001, 211-0003 to 211-0005, 211-0007 (♀); 1♂, same data as holotype (all LWP); 1♂, AUSTRALIA Queensland, 6 km west of Thane, 11.xii.2001, hand-collected, L. W. Popple 28°09'41"S 151°57'59"E, 211-0002 (MSM).

Additional location with audio recordings: Swains Road, Binjour Plateau, Qld, 25°32'00"S 151°29'59"E; Redvale Rd west of Binjour, Qld, 25°31'56"S 151°25'32"E; Yelarbon State Forest, Qld, 28°32'17"S 151°06'22"E (all LWP).

Description. Male (Figs 2B; 5A,B; 6). *Head.* Supra-antennal plate and vertex olive-brown anteriorly, black posteriorly; frons brown with contrasting areas of black colouration posteriorly on each side of medial line; mandibular plates and genae mainly olive-brown and covered by silver–yellow pubescence; small median brown triangular fascia, extending and widening posteriorly from near median ocellus to pronotal margin along the epicranial suture; ocelli pink; compound eyes brown. Postclypeus predominantly black, olive-brown along margins and between the transverse ridges; anterior median area coloured brown or reddish-brown; anteclypeus mainly black; rostrum dark brown; antennae dark brown.

Thorax. Pronotum mainly medium brown, with a lighter brown to olive-brown medial fascia, bordered with black colouration that widens anteriorly of pronotal collar and also towards proximal margin; dorsal and lateral fissures narrowly and diffusely black; pronotal collar olive-brown, with lateral margins ampliate and often darker at extreme lateral margin. Mesonotum with submedial sigilla black, fused anteriorly, with rounded posterior terminations; lateral sigilla black, sharply defined, elongated and narrowing posteriorly area posterior of submedial sigilla with yellow to yellow-brown highlights; remainder of mesonotum, including lateral edges adjacent to lateral sigilla, area surrounding scutal depressions and length of parapsidal suture between submedial and lateral sigilla, olive-brown to brown; scutal depressions black; cruciform elevation dark brown to black; with inconspicuous and sparse silvery-yellow pubescence, more apparent adjacent to wing grooves. Metanotum brown; black medially.

Wings. Fore wing costal vein translucent, olive-brown from base to node, dark brown along remainder; other venation olive-brown to brown, dark-brown distally; basal membrane orange. Hind wing venation brown to light brown, with light brown opaque plaga around margins of anal cell 3, adjacent to vein 3A and vein 2A; six apical cells.

Legs. Coxae and trochanters pale brown to olive brown; meracanthus spikes pale brown to olive-brown, slightly overlapping opercula; fore, mid and hind femora pale brown with weak brown longitudinal fascia developed on posterior, dorsal and anterior faces; fore, mid and hind tibiae pale brown; tarsi mainly pale brown; claws brown, darker apically; spines of fore femora dark brown.

Opercula (Fig. 5B). Broadly rounded; predominantly brown; plates undulating with medial areas slightly depressed.

Timbals (Fig. 2B). Five long ribs; ribs 4–5 both unattached to adjacent ribs and shorter than ribs 1–3; ribs 1–3 fused dorsally, but not ventrally.

Abdomen. Tergite 1 dark brown to black; tergites 2–7 mainly reddish-brown, often dark brown to black on anterior margins, ochraceous on posterior margins, with a weak discontinuous line of dark colouration extending along anterior dorsal and lateral margins; silvery pubescence most prominent along lateral edges of anterior tergites. Sternites olive-brown, often faded to yellow-brown, sometimes paler medially; intersegmental membranes yellow-brown.

Genitalia (Fig. 6). Pygofer with black colouration dorsally, extending to beak and along posterior lateral edges

to upper lobe; ochraceous over the remainder, anal styles light orange; claspers conspicuously elongated, extending posteriorly beyond termination of pygofer, bluntly rounded apically; uncus vertically narrow, relatively short, with rounded termination; Aedeagus trifid, pseudoparameres clearly longer than endotheca; endotheca soft, fleshy.

Female. (Fig. 5C). Similar to male in general colouring and patterning, although often with more extensive areas of paler colouration.

Head. Mainly olive-brown. Supra-antennal plate and vertex pale olive-brown anteriorly, dark brown to black posteriorly; frons olive-brown with contrasting areas of black colouration posteriorly on each side of medial line; mandibular plates and genae pale olive-brown; ocelli pink; compound eyes brown. Postclypeus predominantly olive-brown, tending orange-brown medially, with brown to dark brown longitudinal areas on either side of midline; anteclypeus, rostrum and antennae dark brown.

Thorax. Pronotum as in male, although often with a broader medial fascia. Mesonotum with submedial sigilla brown, separated anteriorly, with slightly darker and rounded posterior terminations, sometimes longer than in male; lateral sigilla dark brown, elongated and narrowing posteriorly, diffuse along margins; area posterior of submedial sigilla with yellow to yellow-brown highlights, as in male; remainder of pronotum, including lateral edges adjacent to lateral sigilla and area surrounding scutal depressions, olive-brown to brown; scutal depressions brown; cruciform elevation dark brown; with inconspicuous and sparse silvery-yellow pubescence, more apparent adjacent to wing grooves. Metanotum dark brown.

Legs. Appearance as in male.

Abdomen. Tergite 1 pale brown; tergites 2–8 mainly reddish brown, with dark lines of black colouration along median dorsal margins; abdominal segment 9 brown to pale brown, with a pair of narrow, diffuse, dark brown dorsolateral fasciae, extending from the anterior margin and not reaching the posterior margin. Sternites pale brown to olive-brown; intersegmental membranes orange-brown. Ovipositor sheath barely extending beyond the posterior termination abdominal segment 9.

Measurements (in mm; range with mean in parentheses: 12 males, 2 females). Body length: male 16.1–19.3 (17.9); female (incl. ovipositor) 18.4–18.9 (18.7). Fore wing length: male 19.0–23.5 (22.1); female 22.9–23.9 (23.4). Forewing length/width ratio: male 2.57–2.86 (2.71); female 2.86–2.90 (2.87). Head width: male 5.1–6.3 (5.8); female 5.6–5.9 (5.8). Pronotum width: male 5.0–6.0 (5.6); female 5.5–6.0 (5.8). Abdomen width: male 4.9–4.9 (5.5); female 5.0–5.3 (5.2).

Distinguishing features. *Clinopsalta semilunata* sp. nov. can be distinguished from *C. adelaida* and *C. autumnna* sp. nov. by having entirely pale brown to pale green sternites without black markings centrally. In most cases, this feature, and a complete lack of fore wing infuscations, distinguishes *C. semilunata* sp. nov. from the *C. tigris* species complex. However, on rare occasions, specimens in the *C. tigris* species complex may also lack wing infuscations and dark central markings on the sternites. In this situation, *C. semilunata* sp. nov. can still be distinguished by having a predominantly dark brown rostrum (c.f. mainly brown or olive in paler specimens of *C. tigris*).

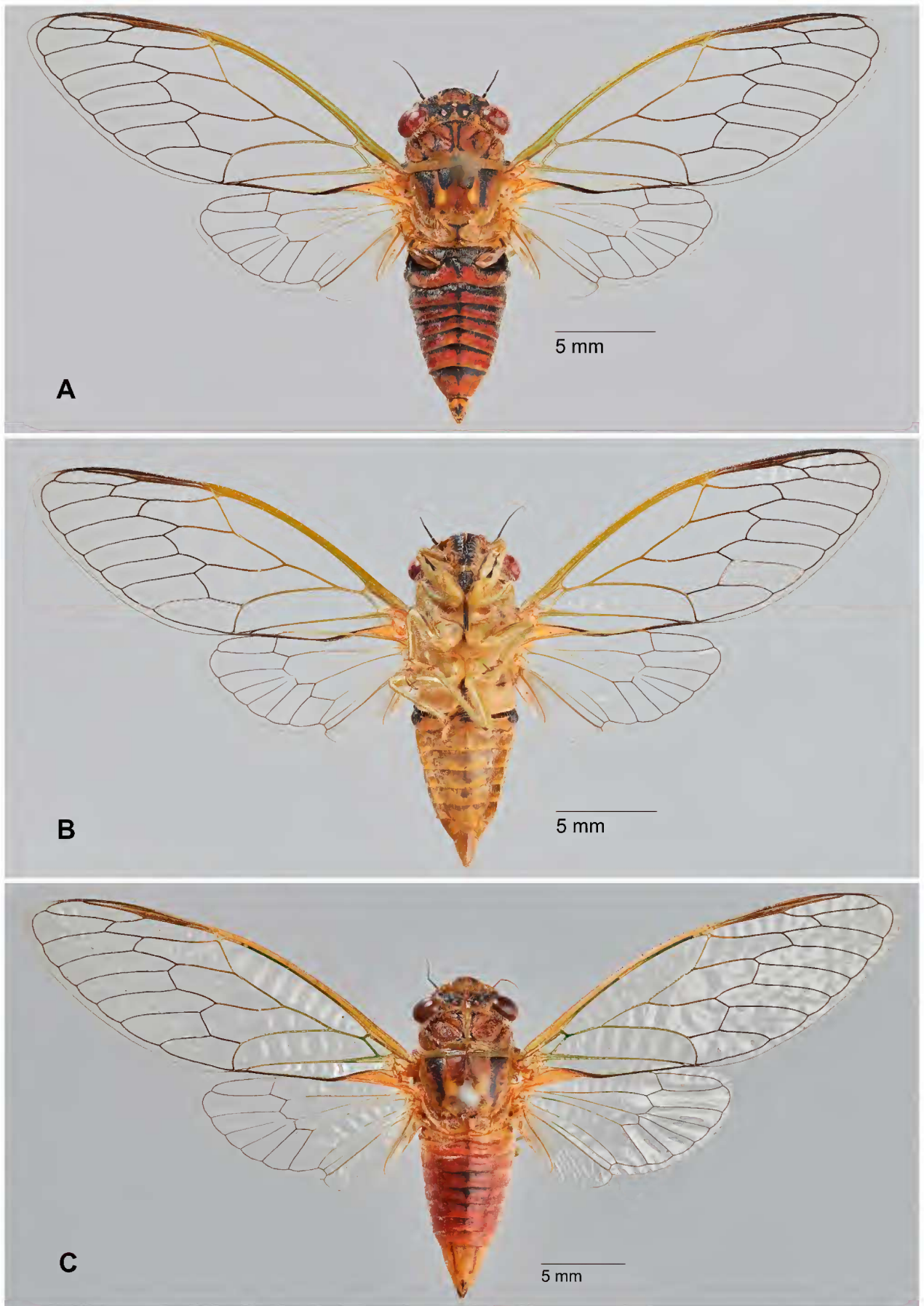


Figure 5. *Clinopsalta semilunata* sp. nov. (A) male holotype, Pratten (28.0912°S 151.7360°E) dorsal habitus; (B) male, ventral habitus; (C) female paratype, 6 km W of Thane (28°09'41"S 151°57'59"E) dorsal habitus.

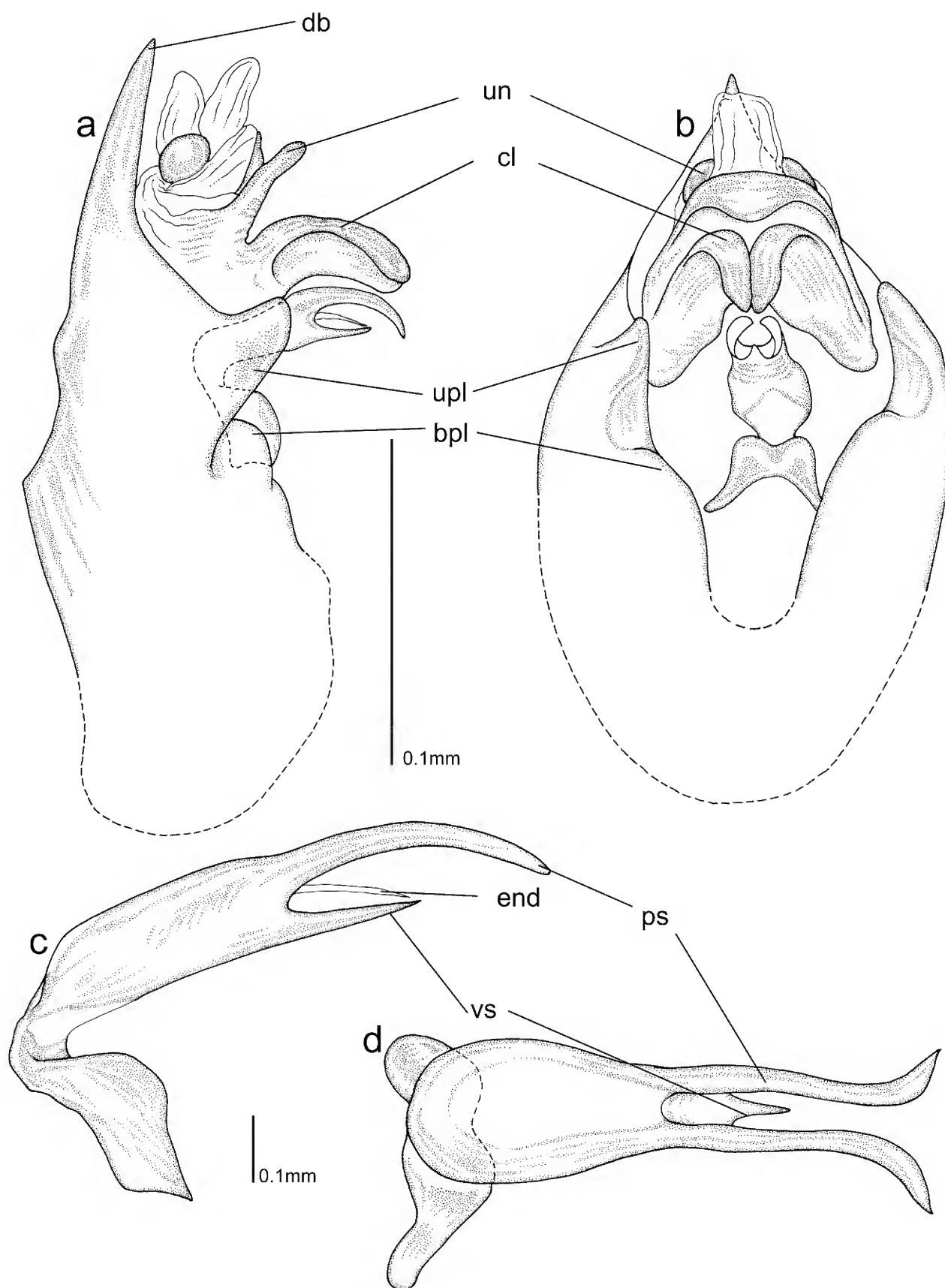


Figure 6. *Clinopsalta semilunata* sp. nov.: illustration of male pygofer and internal genitalia; (a) viewed laterally from the left; (b) viewed ventrally; (c) aedeagus, viewed laterally from left; and (d) apex of theca, viewed dorsally. Characters include: *bpl*, basal lobe of pygofer; *cl*, clasper; *db*, dorsal beak; *ps*, pseudoparameres; *th*, theca; *un*, uncus; *upl*, upper lobe of pygofer; *vs*, ventral support. Specimen from 6 km W of Thane (28°09'41"S 151°57'59"E).

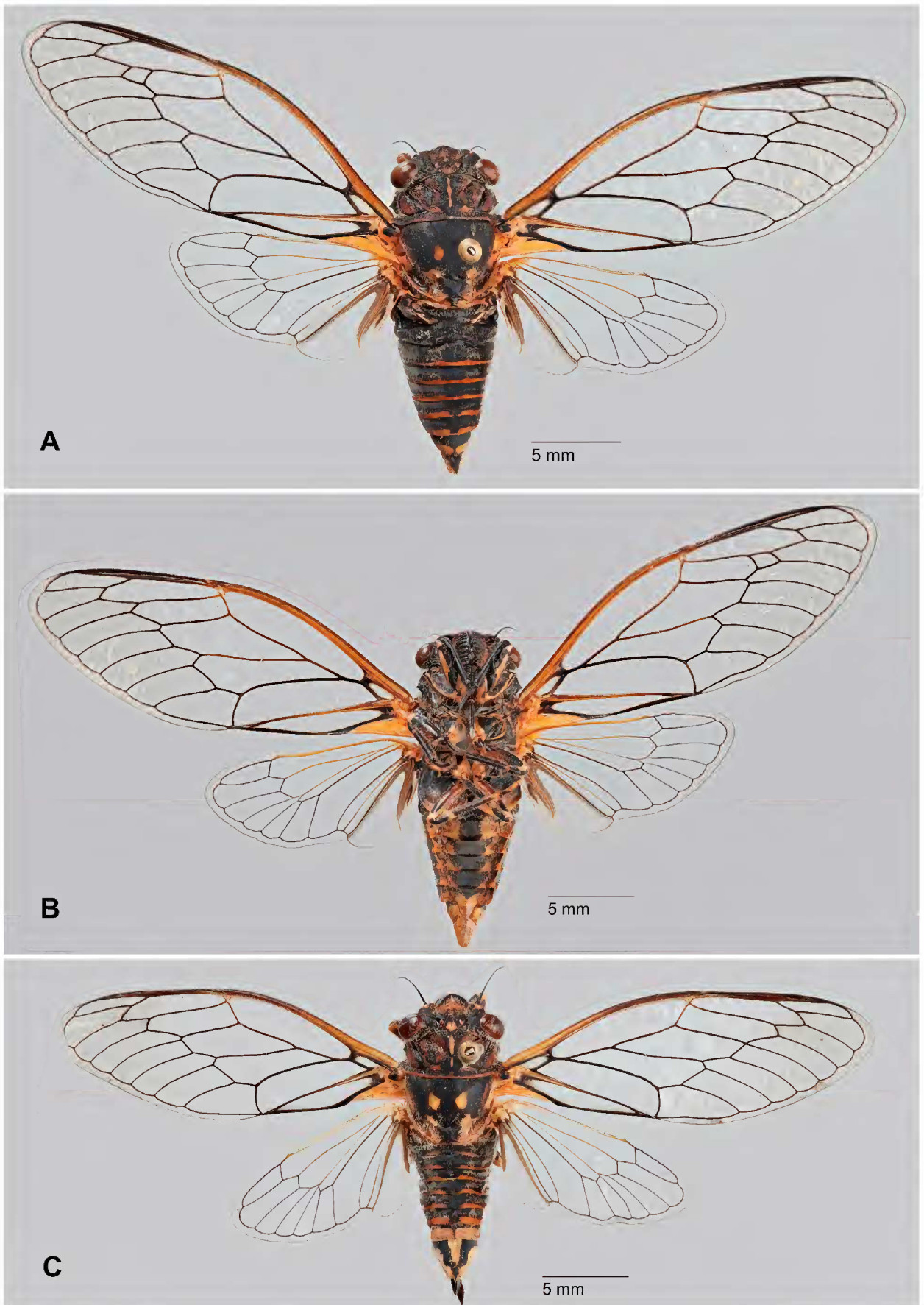


Figure 7. *Clinopsalta adelaida* (A) male, Warrumbungle NPk, NSW (31°18.14'S 149°02.05'E) dorsal habitus; (B) male, ventral habitus; (C) female, Warrumbungle NPk, NSW (31°18.14'S 149°02.05'E), dorsal habitus.

Distribution, habitat and behaviour. *Clinopsalta semilunata* sp. nov. is restricted to south-east Queensland where it is known from east of Yuleba east to Binjour Plateau and south to near Thane and Yelarbon State Forest (Fig. 4). Populations appear to occur in association with wattles (*Acacia* spp.), which grow in the middle storey of dry open forest. At the type locality near Thane, *C. semilunata* sp. nov. appears to occur principally in association with *Acacia caroleae*. Near Yuleba and in the Gurulmundi area north of Miles, it has been found mainly on *Acacia semilunata*. Adults have been observed between September and December.

Etymology. The name is derived from Latin *lunatus*, meaning “moon”, with the prefix *semi-*, meaning “half”. This refers to the bright markings on the mesonotum, which can appear as two “half-moons”. Additionally, the plant *Acacia semilunata* is one of the species with which this cicada is commonly associated in inland southern Queensland.

Additional distribution records for *Clinopsalta adelaida* (Ashton) (Figs 4, 7). 1♂, Wyalong rest area, NSW, 33°55.33'S 147°14.58'E, 22.xi.2010, L. Popple and D. Emery; 1♂ (visual and aural observation only, no specimen), 9.8 km W. of Paskeville, SA, 34.02631°S 137.80837°E, 3.xi.2016, L. Popple and A. McKinnon (both LWP); 1♂, Pilliga State Forest, 70 km N. of Coonabarabran, NSW, 30°40.52'S 149°32.50'E, 2.xi.2012, N. and D. Emery; 1♂1♀, Whitegum Lookout, Warrumbungle NPk, NSW, 31°18.14'S 149°02.05'E, 680 m, 18.x.2014, N., C. and D. Emery; 1♂, same location, 5.x.2015, N., C. and D. Emery (all DE); 2♂♂, Gravesend, NSW, 21.xi.1998, M. Coombs; 2♂♂, Gravesend, NSW, 21.xi.1998, M. Coombs; 1♂1♀, same data as previous, 22.xi.1998; 1♂, 7 km W. of Gravesend, NSW, 21.xi.1998, M. Coombs; 2♂♂, same data as previous, 22.xi.1998 (all MC).

Calling songs

The calling songs of *Clinopsalta adelaida*, *C. autumnna* sp. nov. and *C. semilunata* sp. nov. have clear structural similarities. Each of these species produces a complex day song and a dusk song, although the dusk song of *C. adelaida* has not yet been recorded. The calls broadly consist of regular macrosyllables or echemes, which may or may not be separated by one or more syllables.

The calling song description for *C. adelaida* is based upon a single recording from Telowie Gorge in South Australia (Fig. 8) and two recordings from Wyalong in New South Wales (Fig. 9). The day calling song of this species is the most complex of all described here and has a characteristic sequence. It begins with closely-spaced sets comprising a macrosyllable (0.019–0.023 s duration) followed by three higher amplitude syllables (each 0.007–0.010 s duration), separated by gaps of 0.009–0.015 s duration. This is followed by a sequence of 10–35 syllable doublets (each 0.016–0.019 s duration, punctuated by gaps of 0.015–0.020 s duration). The doublets continue, but are then periodically interrupted by a discrete, higher amplitude macrosyllable (0.040–0.069 s duration) and doublet (or triplet, 0.014–0.022 s duration). This quickly progresses into a stable phrase pattern, with each phrase comprising a high amplitude macrosyllable and doublet followed by a series of three or four lower amplitude doublets. The lower amplitude notes are sometimes augmented with an equivalent number (or fewer) sharp wing-snaps (too subtle in available recordings to allow illustration). These wing snaps

may continue for a short time in the gaps between the high amplitude notes even after production of the low amplitude notes has ceased. A short time later, the wing snaps also cease and only the high amplitude notes (macrosyllable and doublet) remain, with each phrase ending in a long gap of 0.074–0.136 s. The phrases then become simplified even further in the final section of the song when the doublets are also dropped, leaving only the macrosyllables, which are then punctuated by even longer gaps of approximately 0.140 s. This final section is typically the longest part of the song (up to 25 s or longer) and it is during this section that the females are expected to respond with a wing-flick (during the gaps), as indicated by the responsiveness of males to simulated wing-flicks (LWP, pers. obs.).

The day calling song of *C. autumnna* sp. nov. is similar to *C. adelaida*; however its structure is more simplistic and not so strongly transitional. Illustrations of this song are provided in Figs 10–12. The song commences a burst of strident phrases, which are composed of a macrosyllable (0.027–0.055 s duration, 3–6 syllables) followed by two or three single syllables (0.006–0.012 s duration), each separated by gaps of 0.018–0.074 s duration (all statistics, $n = 16$ individual recordings). These may be interrupted by segments in which the syllables (or sometimes all but one of the syllables) in each phrase are replaced by two prominent wing-snaps (e.g. Fig. 11D). In some instances, the song may progress into a sequence whereby the phrases simplify into a single macrosyllable (0.029–0.056 s duration), a brief silence (0.035–0.071 s), a single syllable, double syllable, or shorter macrosyllable (0.009–0.034 s) and a longer silence (0.104–0.148 s). In the final section, the song winds down to a long series of macrosyllables (each 3–6 syllables, 0.031–0.056 s total duration), each separated by long gaps (0.153–0.268 s duration). From the observations of human observers attracting male cicadas using simulated wing-flicks, it is inferred that the female cicada responds with a single wing-flick during the long gap following each macrosyllable in the final section.

The day calling song of *C. semilunata* sp. nov. is the simplest among the species documented here (see Fig. 13). It typically commences with a brief introduction, which is composed of a short echeme (0.071–0.133 s duration), a gap (0.045–0.194), a short sequence of syllables or occasionally syllable doublets (each 0.006–0.015 s duration, punctuated by gaps of 0.041–0.084 s, total duration 0.691–1.283 s), followed by a long gap (0.108–0.377 s duration; all statistics, $n = 17$ recordings). The brief introduction is succeeded by a long series of echemes (each 0.091–0.158 s duration), each separated by a long gap of 0.255–0.373 s duration. As noted for *C. adelaida* and *C. autumnna* sp. nov., observations of simulated attraction of male cicadas indicate that the female cicada responds with a single wing-flick during the long gaps.

Based on examination of a single recording for *C. autumnna* sp. nov. and two recordings of *C. semilunata* sp. nov., the dusk calling songs of these species are both equally simple and monotonous (Fig. 14). In each species, repeated phrases consist of a single discrete syllable followed by a macrosyllable (containing 4–5 syllables). In *C. autumnna* sp. nov., the gaps between each syllable and macrosyllable (and the following syllable) are all of similar duration (0.051–0.082 s duration), whereas in *C. semilunata* sp. nov. the gap following the syllable (0.055–0.064 s duration) is considerably shorter than the gap that follows

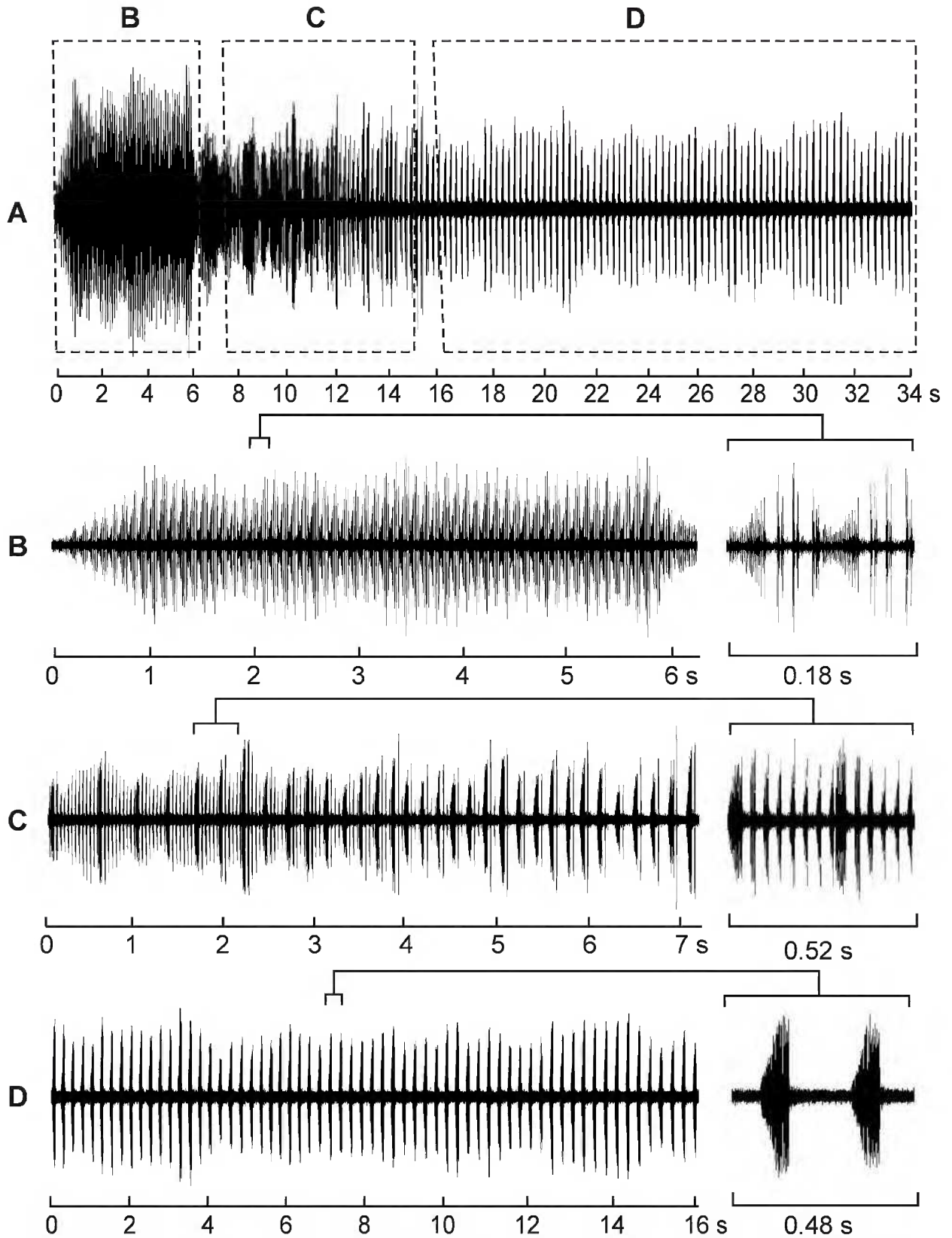


Figure 8. Male calling song structure of *Clinopsalta adelaida*, illustrated in wave plot form. (A) a single, complete bout of calling. (B) expanded diagram of the commencing section (from A above), showing several repeated sets of song notes, each comprising a macrosyllable separated by three syllables, with a magnified example of two sets shown in the excerpt to the right. (C) expanded diagram of the middle of the song (from A), showing several macrosyllables, each separated by a sequence of syllables, gradually reducing to one syllable; an expanded version showing two macrosyllables, each followed by a syllable sequence is shown to the right of the figure. Wing snaps are detectable in the latter half of this section; however these proved too subtle for illustration. D: expanded diagram of the latter half of the song (from A), showing repeated macrosyllables, these again expanded for convenience of examination to the right of the main figure. The recording was obtained in the field from Telowie Gorge, South Australia (33°01'S 138°06'E) by LWP using RS2 (see *Methods and terminology*).

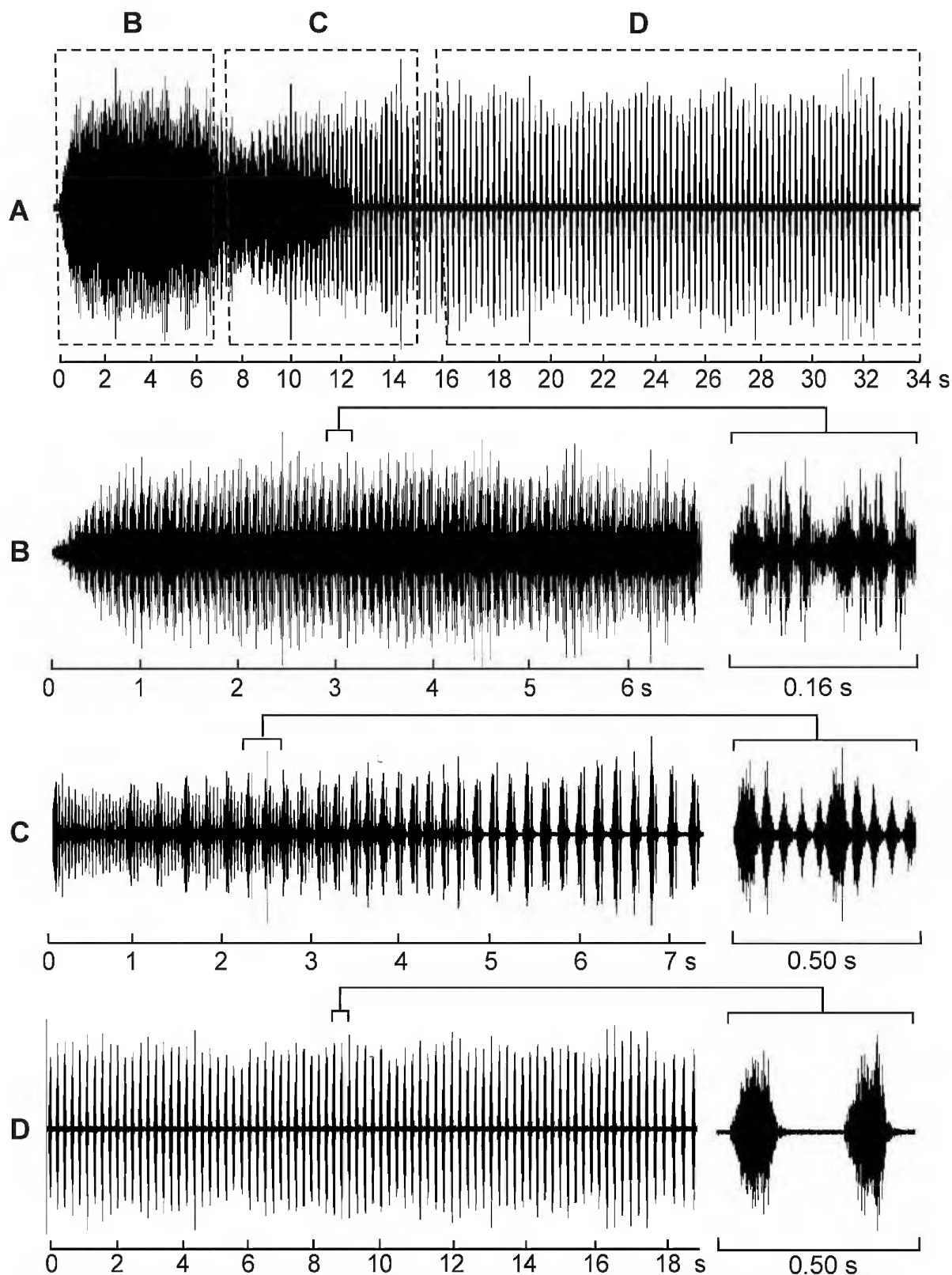


Figure 9. Male calling song structure of *Clinopsalta adelaida*, illustrated in wave plot form. (A) a single, complete bout of calling. (B) expanded diagram of the commencing section (from A above), showing several repeated sets of song notes, each comprising a macrosyllable separated by three syllables, with a magnified example of two sets shown in the excerpt to the right. (C) expanded diagram of the middle of the song (from A), showing several macrosyllables, each separated by a sequence of syllables, gradually reducing to one syllable; an expanded version showing two macrosyllables, each followed by a syllable sequence is shown to the right of the figure. Wing snaps are detectable in the latter half of this section; however these proved too subtle for illustration. (D) expanded diagram of the latter half of the song (from A), showing repeated macrosyllables, these again expanded for convenience of examination to the right of the main figure. The recording was obtained in the field from Wyalong, New South Wales (33°55'S 147°14'E) by LWP using RS4 (see *Methods and terminology*).

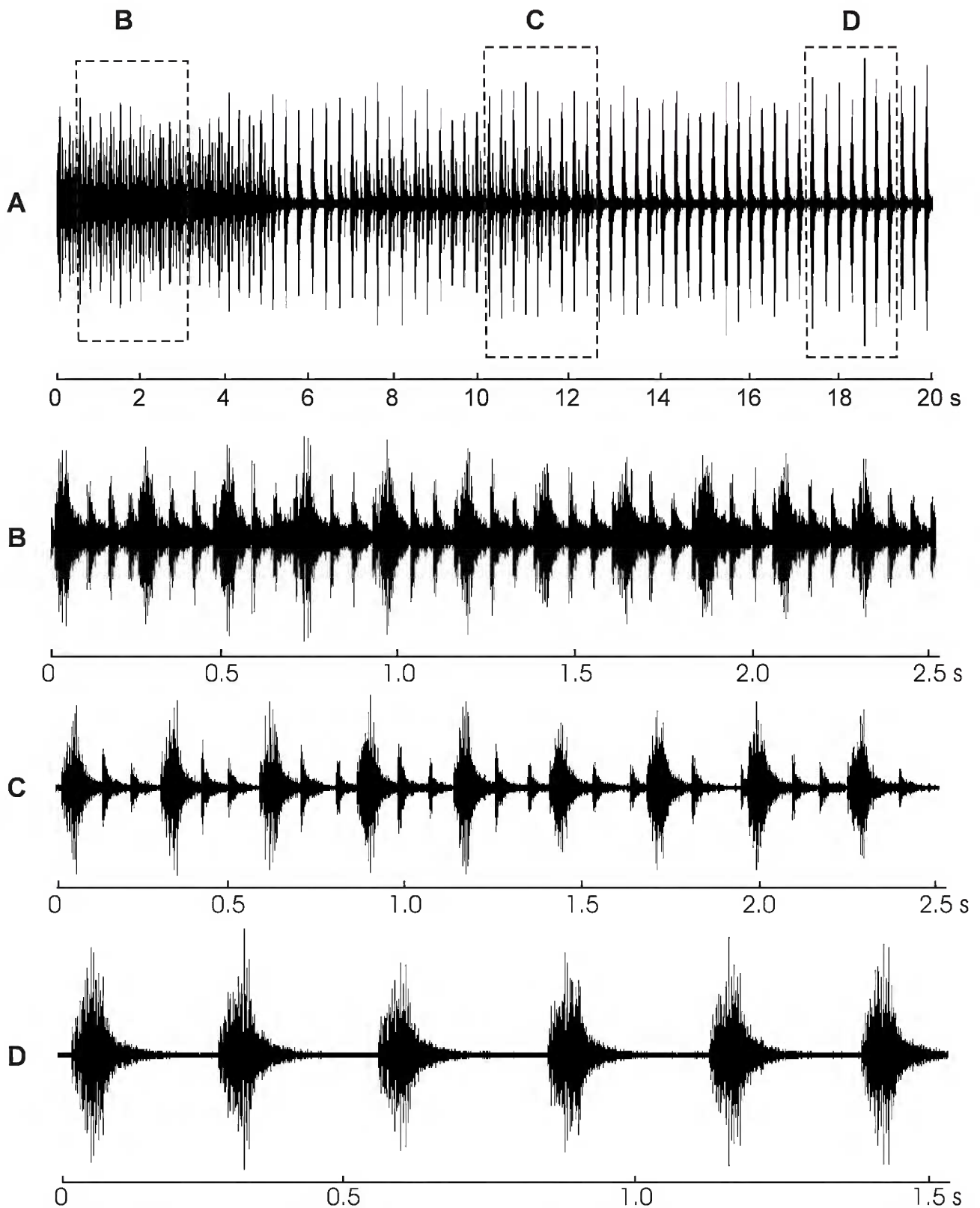


Figure 10. Male calling song structure of *Clinopsalta autumnna* sp. nov., illustrated in wave plot form. (A) a single, complete bout of calling. (B) expanded diagram of the introductory section (from A above), showing several repeated sets of song notes, each comprising a macrosyllable separated by three syllables. (C) expanded diagram of the middle of the song (from A), showing several repeated macrosyllables, each separated by 1–2 syllables. (D) expanded diagram of the latter half of the song (from A), showing repeated macrosyllables. The recording was obtained in the field from Berry, NSW (34°46'S 150°44'E) by LWP using RS1 (see *Methods and terminology*).

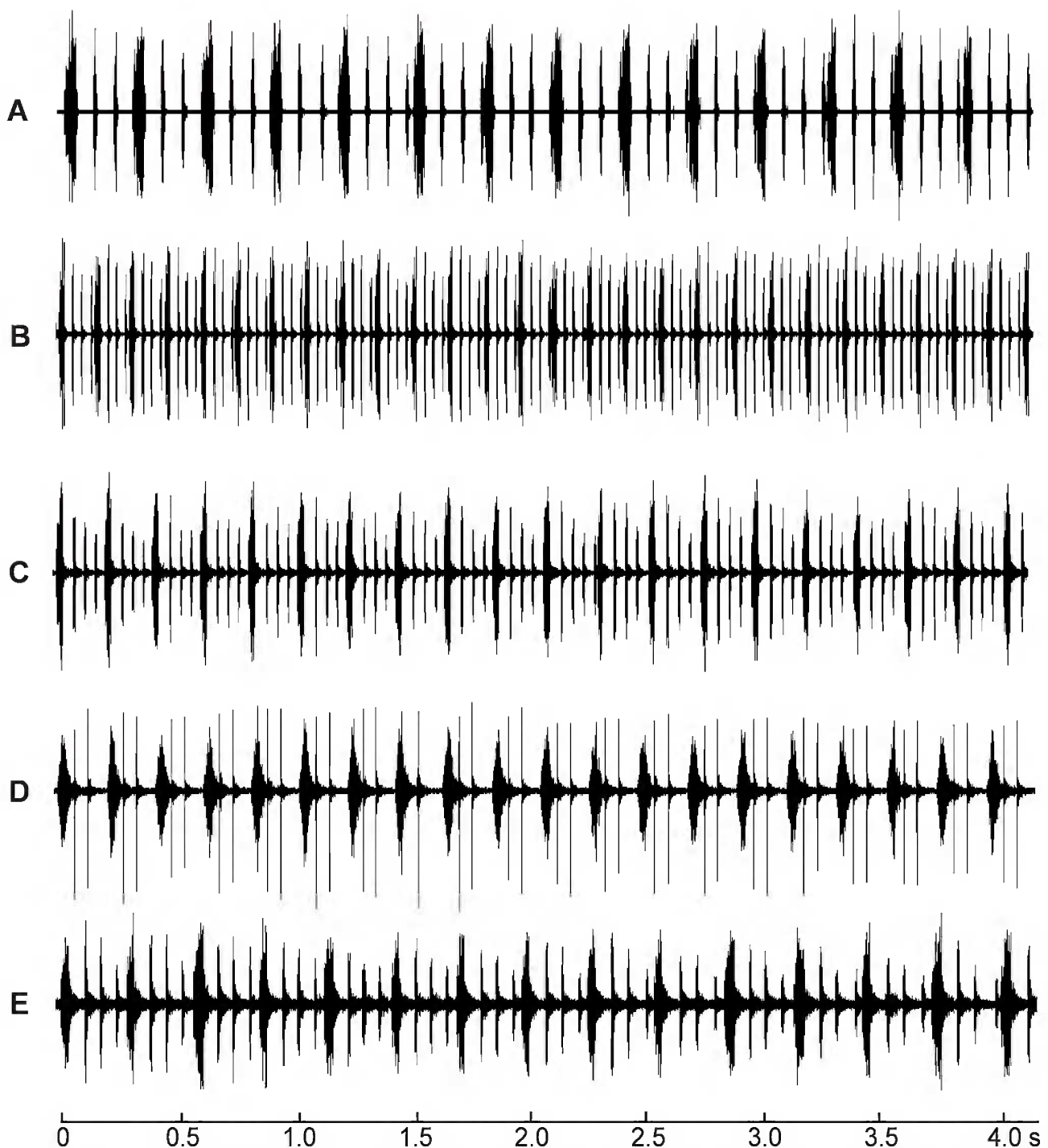


Figure 11. Wave plots illustrating the structure of the complex, introductory part of the male calling song of *Clinopsalta autumnna* sp. nov. from (A) Bargo, New South Wales (34°17'S 150°35'E), (B) Spicer's Gap, Queensland (28°05'S 152°25'E), (C and D) Rosewood, Queensland (27°37'S 152°37'E), and (E) Berry, New South Wales (34°46'S 150°44'E). D provides an example of where timbal-derived syllables (as shown in C) have been replaced with timed wing-snaps. All recordings were obtained in the field by LWP using RS1 (A and E), RS4 (B), or RS2 (C and D) (see *Methods and terminology*).

the macrosyllable (0.123–0.240 s duration). It is considered likely that *C. adelaida* also produces a dusk call even though this has not yet been observed or recorded. The function of the dusk calling songs remains unclear, although the repetitive broadcasting of notes could effectively be interpreted as a simplified version of the day calling song. Therefore, it is likely to play some role in attracting females from the surrounding habitat.

The three species exhibit similar highest amplitude frequency plateaus in their calling songs (Fig. 15). Based on the available recordings, *C. adelaida* has a plateau spanning from 8.8–11.7 kHz (dominant frequency between 10.4 and 11.6 kHz), *C. autumnna* sp. nov. has a slightly higher plateau ranging from 9.0–13.6 kHz (dominant frequency between 9.8 and 12.1 kHz) and *C. semilunata* sp. nov. has a plateau of 8.3–12.3 (dominant frequency between 8.9 and 12.2

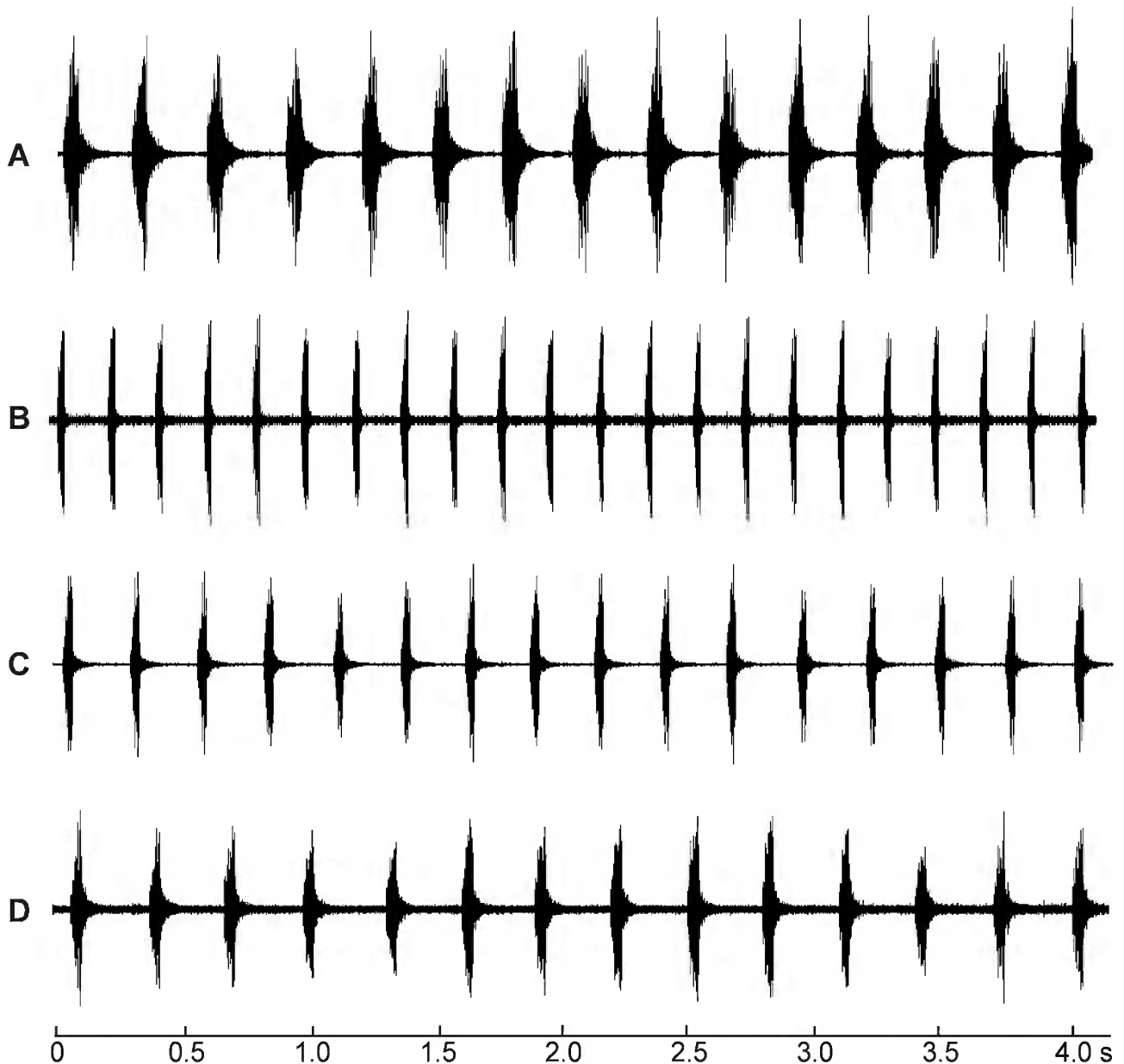


Figure 12. Wave plots illustrating the structure of the simple part of the male calling song of *Clinopsalta autumnna* sp. nov. from (A) Berry, New South Wales (34°46'S 150°44'E), (B) Spicers Gap, Queensland (28°05'S 152°25'E), (C) Rosewood, Queensland (27°37'S 152°37'E), and (D) Bauple, Queensland (25°48'S 152°35'E). All recordings were obtained in the field by LWP RS1 (A), RS5 (B) or RS2 (C and D) (see *Methods and terminology*).

kHz). None of these species exhibits frequency modulations between the day and dusk calling songs or within the different sections of the more complicated day calling songs.

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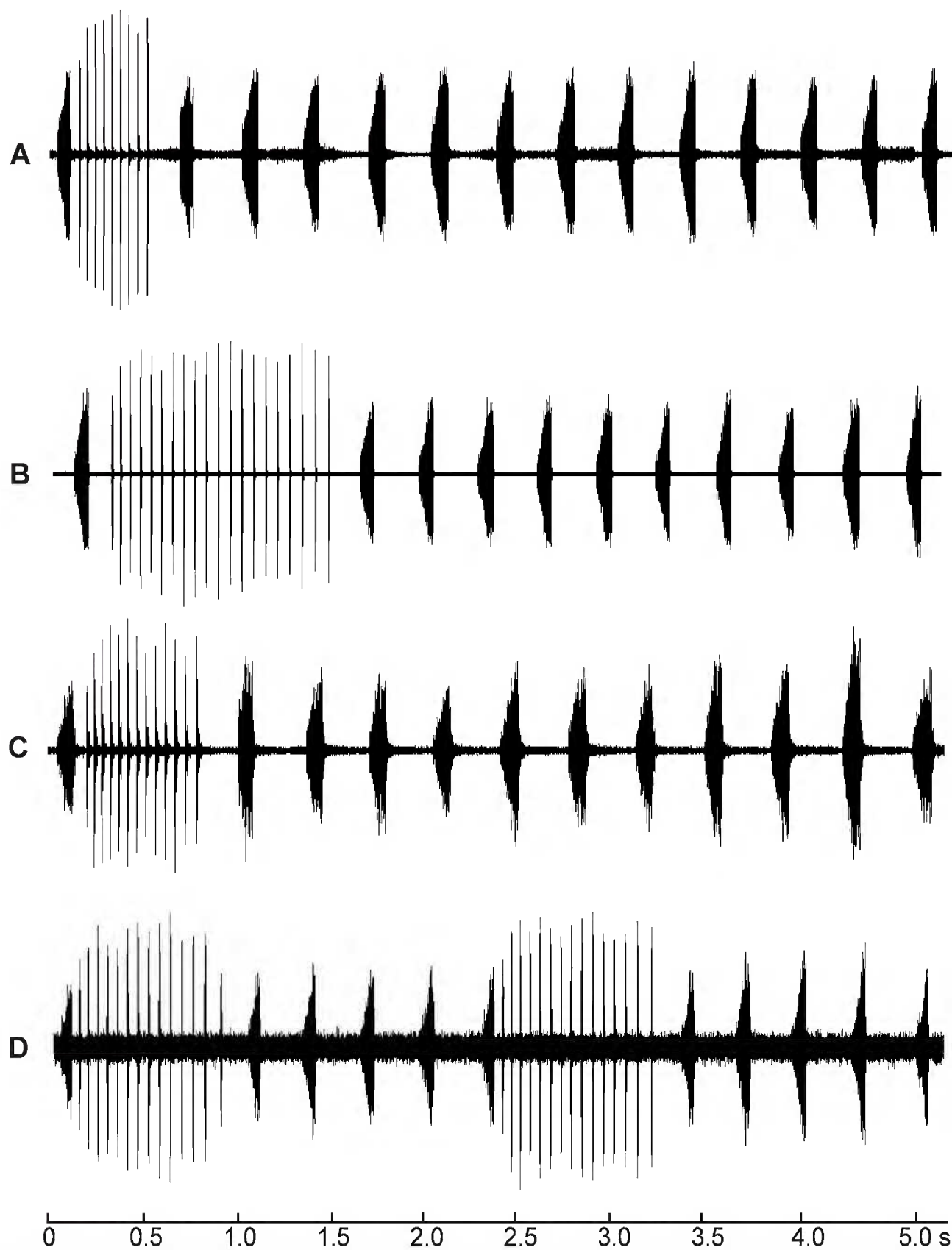


Figure 13. Wave plots illustrating the male calling song of *Clinopsalta semilunata* sp. nov. Each plot shows a separate recording, with a brief introductory echeme and syllable sequence, followed by a series of repeated echemes. Recordings are from (A) Pratten (28°05'S 151°44'E), (B) Yelarbon State Forest (28°32'S 151°06'E), (C) Binjour Plateau (25°32'S 151°30'E), and (D) Chinchilla (26°39'S 150°35'E), all in Queensland. All recordings were obtained in the field by LWP using RS2 (A), RS3 (B) or RS1 (C); or by A. Ewart using RS5 (D) (see *Methods and terminology*).

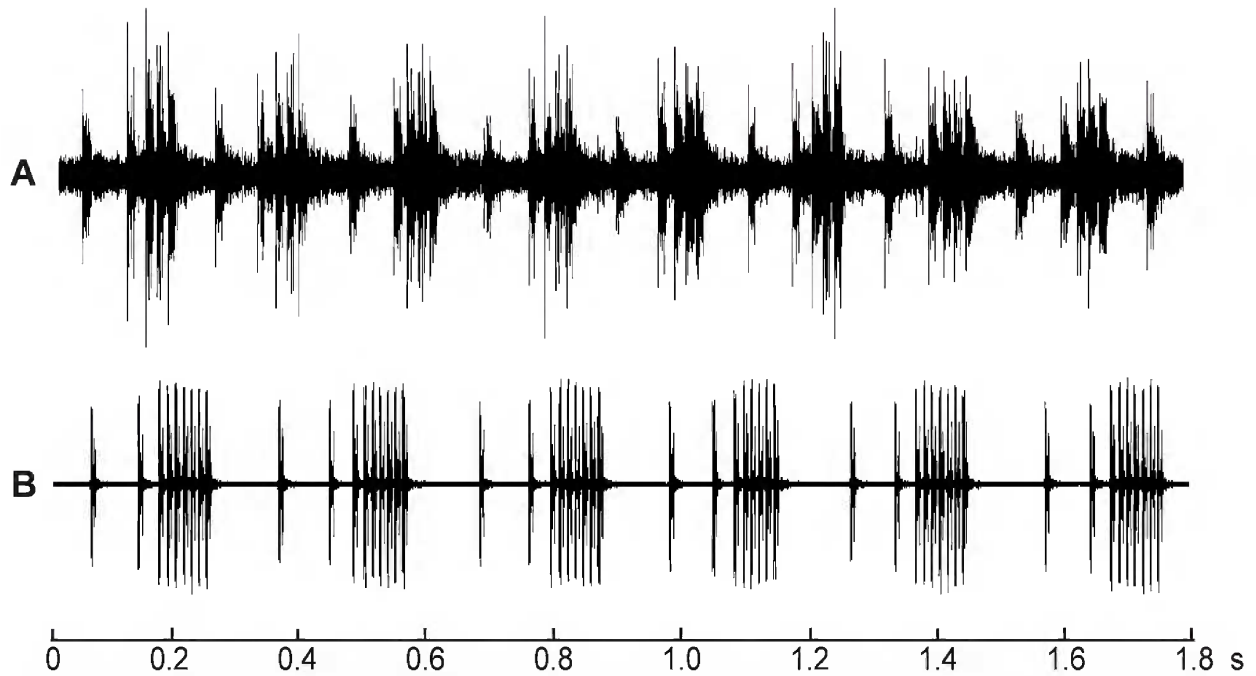


Figure 14. Wave plots illustrating the repeated phrase structure of the male dusk calling song of *Clinopsalta* cicadas, including (A) *C. autumnna* sp. nov. from Cunningham's Gap, Queensland (28°03'S 152°22'E), and (B) *C. semilunata* sp. nov. from Yelarbon State Forest, Queensland (28°32'S 151°06'E). Both recordings were obtained in the field by LWP using RS1 (A), or RS2 (B) (see *Methods and Terminology*).

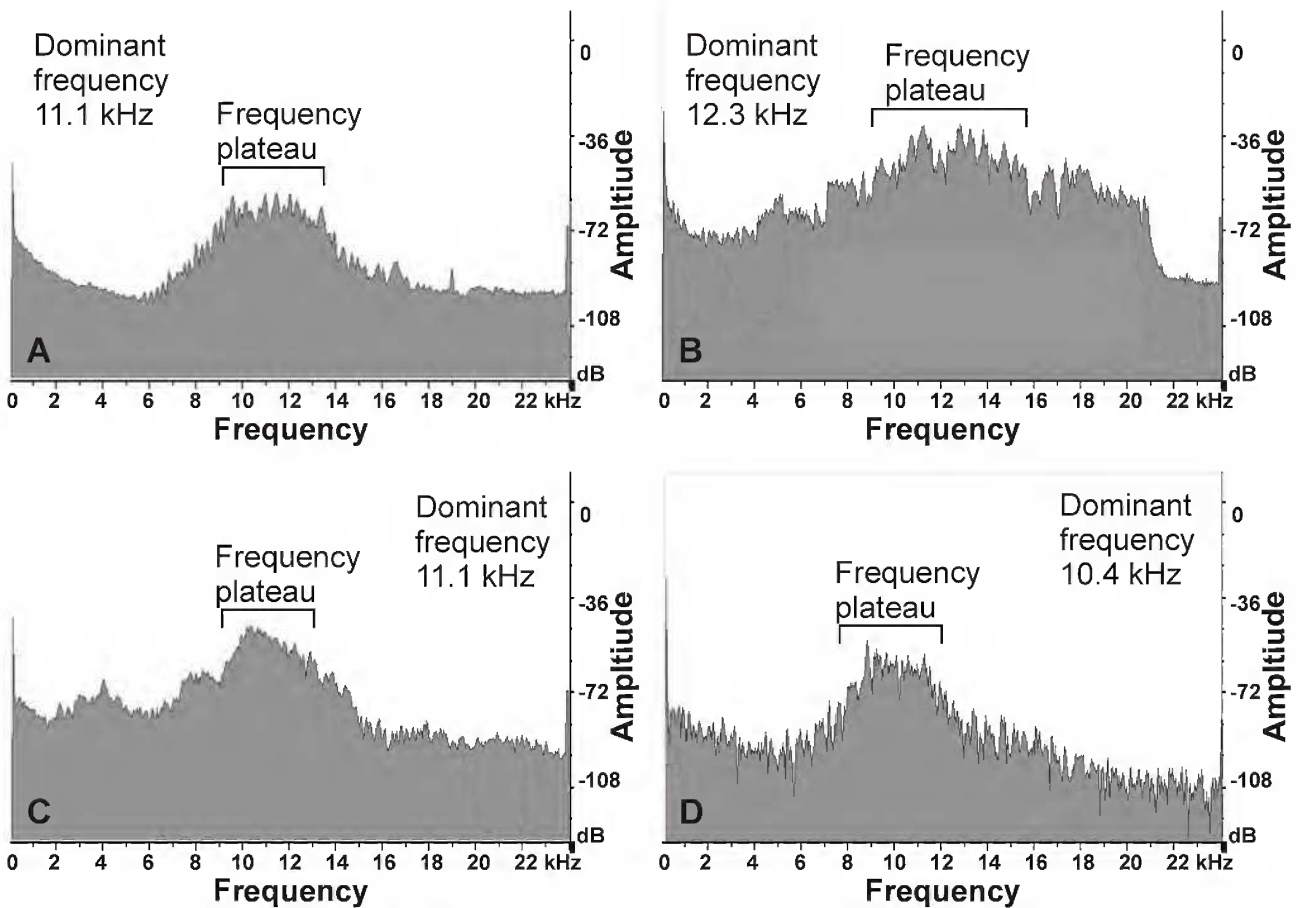


Figure 15. Frequency spectra comparisons between *Clinopsalta* cicadas, including (A) *C. adelaida* (from Wyalong, NSW 33°55'S 147°14'E), (B) *C. autumnna* sp. nov. (from Bargo, New South Wales: 34°17'S 150°35'E), (C) *C. autumnna* sp. nov. (from Redwood Park, Queensland: 27°34'S 152°00'E) and (D) *C. semilunata* sp. nov. (from Pratten, Queensland: 28°05'S 151°44'E). The horizontal bars show the ranges of each highest amplitude frequency plateau (bounded by the 90th percentile of each amplitude spectrum). Recordings were obtained using RS4 (A), RS1 (B and C) or RS2 (D) (see *Methods and terminology*).

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Supplementary audio data

Audio recordings (WAV files) of the following three species are available (Popple, 2017): *Clinopsalta adelaida* (from Telowie Gorge, Wyalong, and Bauple); *C. autumnna* sp. nov. (from Berry, Cunningham Gap at dusk, Rosewood and Spicers Gap); and *C. semilunata* sp. nov. (from Binjour Plateau, Chinchilla, Pratten, Yelarbon and Yelarbon at dusk).

<https://doi.org/10.6084/m9.figshare.5240512.v1>

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